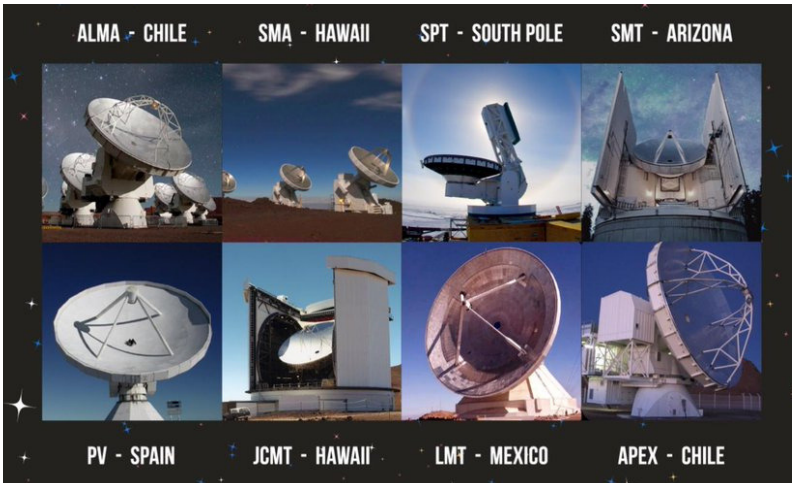
CSBits and Bytes
Highlighting Innovative Computer Science Research
Vol 5, Issue 12

IN A GALAXY FAR FAR AWAY...

After decades of scientific research, an international team of scientists captured the first ever image of a black hole! The Event Horizon Telescope (EHT) snapped a photo of the black hole over 53 million light-years from Earth, at the center of galaxy Messier 87 (M87). Now, one of those astrophysicists is using mathematical simulations to image and predict the behavior of black holes within our own galaxy!

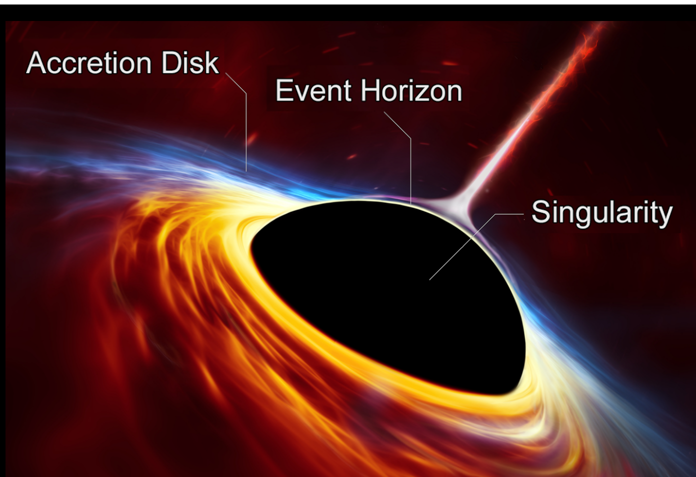


HOW DOES IT WORK?

In order to photograph the M87 black hole, the EHT team first made an Earth-sized telescope. How? They connected and synchronized 8 telescopes around the globe (left), recording data with atomic clocks to precisely measure and time their observations. Each of these telescopes produced a massive amount of data - about 350 terabytes (that's enough data to watch 13.5 years of nonstop DVDs) per day! This data was then analyzed by supercomputers and converted into the final image using new computational tools. What you see is not the black hole itself, but a silhouette of the black hole's gravitational field.

THE EVENT HORIZON

Supermassive black holes, like M87, exert an incredibly powerful gravitational pull from which even light cannot escape! Once matter passes the event horizon into the black hole's **singularity**, nothing can escape or even be seen. Surrounding the event horizon is a spinning mass of matter, called the accretion disk, which gets so hot that it becomes plasma and emits light. This is the light we see in the image. The shadow that the black hole casts on the accretion disk is also seen in the image as a dark region in the middle.



WATCH FOR TURBULENCE

The more turbulently the particles of matter in the accretion disk move, the more difficult it is to see the black hole's shadow. Imagine trying to take a photo of the rocks at the bottom of a stream if the water is moving very quickly, your photo will be blurry. If the water is moving very slowly, however, you can get a much clearer image.

The behavior of the black hole, Sagitarrius A* (Sgr A*), at the center of our own Milky Way galaxy is extremely turbulent and difficult to capture. This is because the EHT only has a 10-hour imaging timeframe. **Dr. Lia Medeiros**, one of the astrophysicists on the EHT team, is developing a new machine learning algorithm to overcome this problem. Her algorithm applies a mathematical method called Principal Component Analysis (PCA) to compare a huge set of black hole simulations to the actual data collected from the EHT. PCA simplifies the amount of information in a dataset by converting complex sets of observations into "principal components." By doing this, Dr. Medeiros will be able to identify variability in the Sgr A* turbulence pattern and help create a clearer image.

THE BOTTOM LINE ▶ Math can bring black holes into focus!

Psst...This Bits & Bytes feature contains hidden links!
When the mouse changes from an arrow to a hand icon, click on the content to learn more.

SPOTLIGHT: LIA MEDEIROS

"The way we do science and engineering now is through computer science, and it's truly amazing the scientific advances that computers have facilitated."

Lia Medeiros is an astrophysicist who who has always been fascinated by black holes. She worked on the EHT project as a graduate student at the University of California Santa Barbara (UCSB). She was awarded a **NSF Graduate Research Fellowship**, which allowed her to expand her research at UCSB to the University of Arizona's **Steward Observatory** and Harvard University's **Black Hole Initiative**.

Lia developed the idea of using PCA to understand the variability of black holes while working on simulations for the EHT as a graduate student. She was recently awarded a **NSF Astronomy and Astrophysics Postdoctoral Fellowship** at the **Institute for Advanced Study**, where she will continue using mathematical approaches to improve imaging of highly turbulent black holes and advance our knowledge about how these cosmic phenomena behave.

LEARN MORE:

Salsa dancing, aerial silks, pottery, barrel racing, running

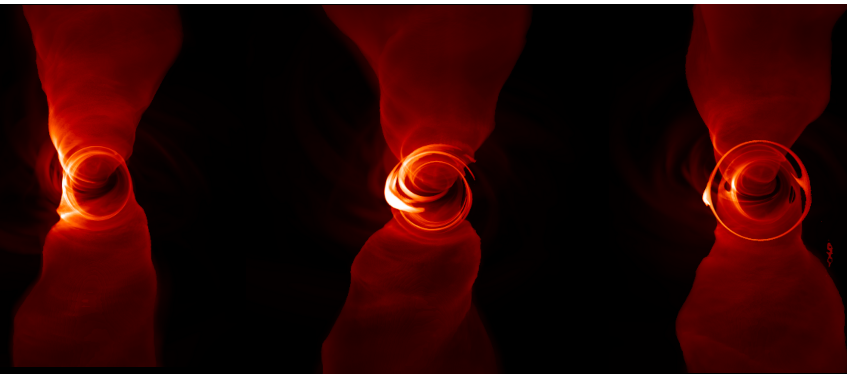
WORDS TO KNOW

Astrophysicist
A scientist who studies space, stars, planets, and the universe

Event Horizon
The boundary of a black hole past which nothing, including light, can escape

Accretion Disk
The swirling disk of matter surrounding a black hole that emits light

Principal Component Analysis
Mathematical method that simplifies complicated data to identify sources of variability



WHAT DO YOU THINK?

Consider three of Lia's simulations of black hole turbulence.

- Can you identify the accretion disk and event horizon in these images?
- What differences do you see between each image?
- How does PCA produce a clearer image of black holes?

TRY IT OUT

Ready to explore a black hole? Design your own spacecraft, and try to pass the event horizon in **this DIY board game**!

Links in this issue:
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